Potential Energy Efficiency Policies and Programs

For consideration by Governor's Renewable Energy and Energy Efficiency Working Group
Jeff Schlegel; September 17, 2004 (revised)

1. Adopt WGA Energy Efficiency Proposed Objective
Increase the efficiency of energy use by 20% by 2020.

2. Energy Savings Goals for Public Facilities (save X% by Y year)
- ARS 34-451. Reduce energy use in public buildings by ten per cent per square foot of floor area on or before July 1, 2008 and by fifteen per cent per square foot of floor area on or before July 1, 2011, using July 1, 2001 through June 30, 2002 as the baseline year.
- Expand to community colleges and public schools
- Consider for municipalities, counties

3. Other Energy Efficiency Goals, Policy Goals (e.g., % of load growth; per capita)
(See SWEEP handout on potential/example goals, December 2003)

4. Energy Efficiency Performance Standard
Similar to Environmental Portfolio Standard (EPS), but for energy efficiency

5. Utility Demand-Side Management (DSM) Programs
- ACC-regulated utilities (ACC proceedings, goals, plans, ratepayer funding)
- SRP, public utilities, coops

6. Building Codes
- Support energy efficiency in building codes, code upgrades, code support, training
- Consider statewide building codes (commercial is priority)

7. Appliance and Equipment Energy Efficiency Standards
- Support for Federal standards
- State equipment efficiency standards through state legislation

8. Increase Leverage for Federal Programs
Building America, Rebuilding America, other programs

9. Increase Efforts for Municipals and Schools Programs
- DOC/EO work with municipalities
- Direct SFB (with DOC/EO support) to increase energy efficiency in schools

10. Energy Surety, Targeted Distributed Resources
Support integrated programs to encourage distributed resources (energy efficiency and distributed generation, including renewables), especially in load pockets for critical needs

11. Tax Incentives
Consider revisions of tax assessment ratio

12. Hook-Up or Impact Fees
Reduced fees for more efficient (and smaller?) houses

FUEL NEUTRALITY

Ratepayer-funded DSM shall be developed and implemented in a fuel-neutral manner, in accordance with the State of Arizona statutes. For those installations/applications that have multiple fuel choices, source energy should be a part of the analysis. Programs promoting distributed generation, combined heat and power, and/or other technologies that reduce peak demand or conserve energy may be approved by the Commission.

Time Dependent Valuation of Energy

for Developing Building Efficiency Standards

Time Dependent Valuation (TDV) Formulation 'Cookbook'

April 12, 2002

Submitted to:

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Overview

The Title 24 building standards are based upon the cost-effectiveness of efficiency measures that can be incorporated into new buildings in California. The standards promote measures that have a greater value of energy savings than their cost. The Title 24 standards are flexible enough to allow building designers to make trade-offs between energy saving measures using computer analysis methods that evaluate the relative energy performance. For example, the energy losses from having more windows in a building design can be offset by better insulation or a higher efficiency air conditioner. Historically, within the Title 24 methodology, the value of energy efficiency measure savings has been calculated on the basis of a "flat" source energy cost, which does not vary by season, or by day-of-the-week, or by time-of-day.

The concept behind time dependent valuation (TDV) is that energy efficiency measure savings should be valued differently at different times to better reflect the actual costs to users, to the utility system, and to society. For example, the savings of an energy measure that is very efficient during hot summer weekday afternoons would be valued more highly than a measure that achieves efficiency during the off-peak. This kind of savings valuation reflects the realities of the energy market, where high system demand on summer afternoons drives electricity prices much higher than during, say, night time hours in mild weather.

The outcome of the TDV project is the development of a rational method for deriving time dependent valuations for energy savings, and we propose that this method be adopted as the basis for Title 24 energy savings calculations. Doing so would allow the Title 24 efficiency standards to provide more realistic signals to building designers, encouraging them to design buildings that perform better during periods of high energy cost.

This "Cookbook" documents the TDV methodology, so that people interested in this proposed change to Title 24 may better understand it. If you are interested in how this method is implemented in a spreadsheet contact the authors for a copy of the spreadsheets used to create the TDV values.

Before delving into the details, however, it may be helpful to explain some of the basic concepts and assumptions incorporated into the TDV methodology.

1) **Rational and Repeatable Methods**
We have used published and public data sources for the fundamental analysis approach to developing TDV data. This will allow future revisions of the Standards and their underlying TDV data to be readily updated when called for by the California Energy Commission (CEC).

2) **Based on Costs Not Rates**
We have avoided using actual rates because they are based on averages over time periods and are influenced by many factors other than cost. Furthermore, there are numerous rates among the different utilities, and the rate schedules are changed frequently, so it would be unclear which to choose for the basis of standards over a long time period. However, the hourly TDV values have been adjusted so that the average customer would have the same bill using TDV values as the average class rate.

3) **Seamless Integration within Title 24 Compliance Methods**
We have assumed that the mechanics of TDV should be transparent to the user community, i.e., that compliance methods should remain familiar and easy, and that any computational complexities will take place in the "black box" where the user need not be concerned with the details.

4) **Climate Zone Sensitive**
As with the weather data used for Title 24 performance calculations, which allow building designs to be climate responsive, the TDV methodology should also reflect differences in cost values driven by climate conditions. For example, an extreme, hot climate zone should have higher, more concentrated peak energy costs than a milder, less variable climate zone.

5) **Hourly Valuations**
TDV is based on a series of 8760 values of energy cost, one for each hour of the typical CEC weather year. TDV values are available for each of the sixteen climate zones, for residential and for nonresidential buildings, and for electricity, natural gas and propane. Hourly energy savings estimates for a typical year are developed for a given building using a CEC-approved computer simulation tool, and those savings are then multiplied by each hour's TDV value. The sum of these values is the annual savings.

6) **Components of TDV for Electricity**
The TDV method develops each hour's electricity valuation using a bottom-up approach. We sum elements of forward-looking incremental costs, and then scale up to equal the average retail price for residential and non-residential customers. The resulting hourly TDV valuations vary by hour of day, day of week, and time of year. The components are:

a) Generation Costs – *variable by hour* – The total annual generation cost for electricity is allocated according to long term CEC generation forecasts of wholesale electricity prices, which vary by month, by day of week and by hour.

b) T&D Costs (transmission and distribution) – *variable by hour* – The total annual T&D costs, allocated as a function of outdoor temperature in the CEC weather files by climate zone, with the highest costs allocated to the hottest temperature hours. Non-peak hours are not allocated any T&D costs.

c) Revenue neutrality adjustment – *fixed cost per hour* – The remaining, fixed components of total annual utility costs – taxes, metering, billing costs, etc. – are then calculated and spread out over all 8760 hours. The result, when added to the previous two variable costs for the year, is an annual total electricity cost valuation that corresponds to the total electricity revenue requirement of the utilities.

d) Emissions Costs – *variable by hour* – Total annual emissions costs, as determined by emissions trading prices, are usually embedded in total electricity rates. Under TDV, we allocate these costs, higher or lower, to different hours, based on generation costs – during high cost hours, the less efficient peaker plants, with their higher emissions costs, come on line. These costs are optional - their inclusion is based on a policy decision on whether the stringency of the standards should be based purely on the economic efficiency - or on a metric that places an economic value on reduced air emissions from energy efficiency.

7) **Combined Electricity Costs**
The following graph illustrates how the component costs add up over a Monday to Friday summer work week. The Wednesday of that week is very hot so that some of the T&D costs are allocated to the middle of the week shown in orange. The top of the curve represents the total cost for each, while the different colored regions indicate how much of each component contributes to each hour.

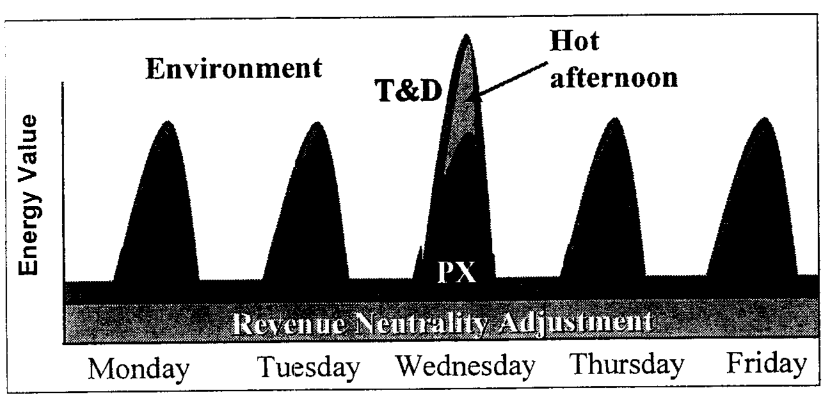


Figure 1: Hourly Variation In Components of Electricity Cost During Summer Weekdays

8) **Components of TDV for Natural Gas**

The natural gas TDV is taken primarily from the CEC retail price forecast. The components are:

a) Retail price forecast - monthly variation - The natural gas forecast is based on the long-run forecasts by the CEC. There is a monthly variation in natural gas retail prices, but not an hourly variation.

b) Emissions Costs - fixed cost per hour - The emissions costs are based on emissions trading prices and the rates of emission for natural gas and propane combustion. This is an optional component based on a policy decision on whether to value air emission reductions from energy efficiency.

9) **Combined Natural Gas Costs**

The following graph illustrates the components for natural gas.

Figure 2: Monthly Variation in Natural Gas Components

10) **Components of TDV for Propane Costs**

The components of propane vary by month like natural gas, but has more components because there is not a monthly retail CEC propane forecast available. The components are;

a) Commodity Cost - monthly variation - The propane forecast is based on the long-run DOE forecast. There is a monthly variation in propane commodity costs, but not an hourly variation

b) Revenue neutrality adjustment (retail markup)- fixed cost per hour - The remaining, fixed components of total delivered propane costs are calculated and spread over all hours. Since the delivery component for propane are flat throughout the year, these are included in the revenue neutrality adjustment. Since propane is an unregulated market, the revenue neutrality adjustment is equivalent to the "retail markup" a distributor would charge on top of the wholesale price.

c) Emissions Costs - fixed cost per hour - The emissions costs are based on emissions trading prices and the rates of emission of propane combustion. This is an optional component based on a policy decision on whether to value air emission reductions from energy efficiency.

11) Combined Propane Costs

Figure 3 shows the monthly variation breakdown of the propane costs.

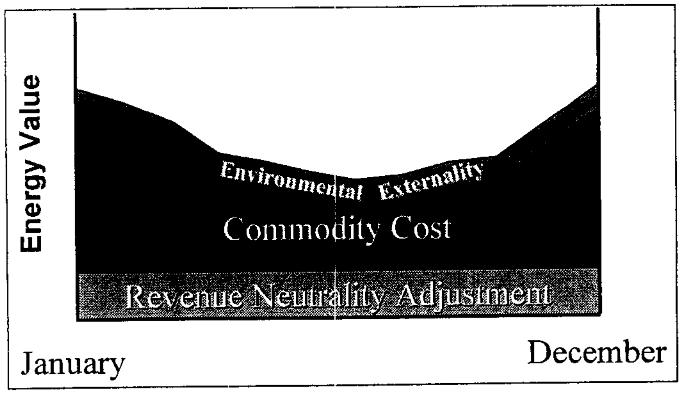


Figure 3: Monthly Variation in Propane Components

In conclusion, the TDV methodology provides a way to allocate the value of energy savings in a way that reflects the real costs of energy over time. While the details of the methodology, laid out in the remainder of this report, can be complex, at root the concept of TDV is quite simple. It holds the total cost of energy constant at forecasted retail price levels. It then gives more weight to on-peak hours and less weight to off-peak hours. The overall stringency of the Title 24 standards would not be changed by adopting this version of TDV, but measures that perform better on-peak would be given somewhat greater value than measures that do not. For many measures, which perform about the same in both peak and off-peak time periods, TDV would have little or no effect. Over time, Standards based on TDV would tend to reduce the peak demand characteristics of the building stock in California, which would benefit consumers, utilities and the environment.

Summary of Data Used in TDV Calculations

The following table summarizes the input data used in the calculation of the TDVs. The actual numbers for each of these are included or referenced in the attached appendices. For each of following equations, the data sources are listed below the equation and specific, cross-listed references are provided in the Appendix.

Table 1: Data Sources for TDV

Data	Source	Vary by Climate Zone?
Weather Data	Climate zone data used for standards evaluation	Yes - each zone has its own weather
Electric Class Shapes	1999 utility statistical load profiles used in billing	Yes - varies by utility
Electric Retail Rates Forecast	CEC forecast 2005 to 2034 for each IOU, res and non-res	Yes - varies by utility
Annual Wholesale Electric Price Forecast	CEC forecast 2005 to 2034 for each IOU	Yes - varies by utility
Hourly wholesale electric price shape	CEC (shape based on Richard Griz forecast)	No - system value used in all CZs
2005 Natural Gas Wholesale Price used in estimating electricity emissions component	CEC forecast average 2005 EG cost for each IOU	Yes - varies by utility
Emission rates by power plant type	E3 study	No
Emission costs by pollutant	E3 study	No
Natural Gas TDV Streams	CEC forecast retail gas rate - monthly 2005 to 2034 - residential and commercial	Yes - varies by utility
Oil Price forecast (propane assumed to follow oil price trend)	DOE EIA projection of oil prices through 2019, extended through 2034 by 10 year trend	No
Monthly propane price shape	DOE EIA Petroleum Marketing Monthly publication	No
Monthly propane consumption shape	DOE EIA Petroleum Marketing Monthly publication	No
Average propane price	DOE EIA Petroleum Marketing Monthly publication	No

Climate Zone Mapping

The data for each respective utility described above were mapped to climate zone with the following mappings. For those climate zones with more than one utility, the utility shown in bold was used. This was selected by using the utility that serves the most customers in the zone.

Table 2: Climate Zone Mapping

Climate Zone	Utility
1	PG&E
2	PG&E
3	PG&E
4	PG&E
5	**PG&E** (SCE)
6	SCE
7	SDG&E
8	SCE
9	SCE
10	**SCE** (SDG&E)
11	PG&E
12	PG&E
13	PG&E
14	**SCE** (SDG&E)
15	**SCE** (SDG&E)
16	**PG&E** (SCE)

1.0 Introduction: TDV Formulation

The process used to calculate the TDV values is documented in this 'cookbook' so that all interested stakeholders can understand the mechanics behind developing Time Dependent Values (TDVs).

The existing Title 24 standards are based on energy trade-offs between the value of reduced energy consumption and the cost of improving efficiencies of residential and non-residential buildings. Currently, these costs are made based on a 'flat' valuation so that energy saved is valued equally regardless of the time of day and year the improvement is made.

This proposed process develops Time Dependent Values (TDVs) that would replace the current 'flat' costs used in the standards. The same basic approach is used to develop the lifecycle TDV values for each of the three fuels affected by the standards; electricity, natural gas, and propane. In each case, this revision makes a number of changes from the existing values used as the basis of the Title 24 Building Standards. Rather than a single value per quantity saved of electricity, natural gas, or propane regardless of time of year, or location this valuation has variation by month and area.

The underlying concept behind these values is to reflect the underlying hourly 'shape' of the total costs of each fuel including wholesale market costs, delivery, and emissions externality costs, and the 'level' of forecasted retail rates. The average residential and non-residential load shapes will result in the same total energy cost using TDVs as with retail rates. However, because the societal costs are higher during peak use of each of these fuels, energy savings during the peak periods would be emphasized. Energy savings during off-peak periods would be de-emphasized.

In comparing the three energy sources of interest (electricity, natural gas and propane) the following differences should be noted:

- The emissions adder is time varying for electricity only. This is due to differences in power plant efficiency as they are dispatched. More expensive (peaking) plants are less efficient and emit more pollutants per kWh than plants operating off-peak. In contrast combustion of natural gas and propane is assumed to emit the same level of pollutants per therm of fuel regardless of time of day, or season.

- When the trade-off values for Title 24 were developed for the 1992 standards, there was no explicit value calculated for propane. The values for natural gas were used as a proxy for propane. In the TDV method, propane is treated individually as its own fuel source.

This cookbook is organized into a chapter for each of the three energy sources. In each chapter, the complete derivation of the TDV values for each is provided. The process is broken down into steps, and each step is accompanied by a flow chart of the data required for that calculation, as well as an equation. The calculations are presented in order so that all of the inputs to a particular calculation are either direct inputs, or the result of previous calculations. In almost all cases, the direct inputs have been selected from public sources such as the California Energy Commission reports. These have been referenced and are included in an appendix for the data sources.

In addition to this manual, there is a set of spreadsheets that calculate the TDVs for each climate zone. The equations in this manual are identical to those used in the spreadsheet. The spreadsheet will be useful if you would like to recreate the values using different input data, look at how the calculation is made, or analyze the sensitivity of an input assumption to the final TDV values.

Finally, the indices used in the equations are the following:

y = year
z = climate zone
m = month
h = hour
c = customer class (residential and non-residential)

2.0 Electric TDV Calculations

2.1 Annual Average Wholesale Cost

The California Energy Commission forecast developed by the Electricity Analysis and the Demand Analysis Office provides the long-run wholesale and retail rate forecasts used in the development of the TDV values for electricity in the years 2005 through 2034 as referenced below. The detailed forecasting methodology can be found in the "2002-2012 Electricity Outlook Report", published by the California Energy Commission in February 2002. This Outlook Report describes the methods and data used to develop the CEC forecast only through 2012.

As of March 2002, the following link points to the Outlook Report:

- http://www.energy.ca.gov/electricity_outlook/documents/index.html

Equation #1 below reflects the annual average wholesale electricity cost developed by the CEC in \$/kWh.

Annual Average
Wholesale Cost
Forecast
(EQ #1)

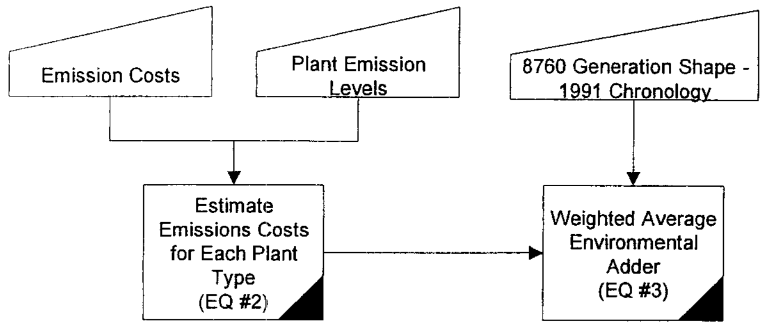
Equation 1: Annual Average Long-run Generation Cost Forecast

$$\text{Annual Average Generation Cost}\left(\frac{\$}{kWh}\right)_{y,z} = \text{CEC Forecast}\left(\frac{\$}{kWh}\right)_{y,z}$$

Data Sources:

A: California Energy Commission Wholesale Generation Forecast

2.2 Emissions Costs



Equation 2: Estimate Generation Emissions Costs by Hour

$$Emissions\ Cost\left(\frac{\$}{MWh}\right) = \sum_{y=1}^{15/30} \frac{Emission\ Cost\left(\frac{\$}{ton}\right) \times Emission\ Level\left(\frac{tons}{MWh}\right)}{[1+r]^{y}}$$

The emissions costs for each generation plant type are estimated by multiplying the assumptions on emissions costs times the amount of emissions. Values of the emissions costs are based on a] market costs as experienced in emissions trading, and b] emissions abatement costs. This study was done for the TDV project, and the final report is included in the appendix on data sources. The following tables show the results of the inputs derived from this study, and the results of the calculation of emissions externality costs by plant type.

Table 3: Emissions Cost for NOx and CO2

Cost $/ton	NOx	CO2
E3 Recommendation	$ 3,068.75	$ 9.21

Table 4: Emissions Rates for Each Generation Type

Emissions (tons/MWh)	NOx	CO2
CCGT with SCR	0.000075	0.4
Steam turbine	0.00085	0.6
CT with SCR	0.0002	0.8

Table 5: Emissions Costs per MWH of Each Generation Type

Cost $/MWh	CCGT	Steam Turbine	CT
E3 Recommendation	$ 3.91	$ 8.13	$ 7.98

In order to apply the emissions costs by hour for the TDV values, the marginal plant in each hour is estimated based on the market price in each hour. The marginal plant is the plant whose production would be first reduced if load is decreased. Then the present value over the 15-year and 30-year life is calculated for the residential and non-residential standards. The marginal plant is determined by dividing the short-run operating cost of different plant types (based on assumptions of heat rate, fuel cost, and O&M) by the annual average generation cost. These assumptions and the resulting variable operating costs of each plant type are provided in Table 6, below. The short-run costs include losses to deliver to the wholesale market to make them comparable to the average annual generation costs.

Natural Gas Commodity Forecast

The 20-year forecast methodology was extended to a 30-year forecast for the purposes of the TDV calculations. The North American Regional Gas (NARG) model, a general equilibrium model, is used to determine natural gas prices and demand at the California border and at in-state locations for a 20-year forecast using 5-year increments. The model assumes an inelastic demand curve for gas. Pipeline and resource cost assumption data are adopted from FERC (2000) and USGS (1995), respectively. The costs include the values for resource production and pipelines, whereby a commodity cost and an interstate cost are calculated. To extend beyond the 20 year forecast, the growth rate of the previous 7 years was applied to the annual values after 2022.

Table 6: Short-run Costs by Plant Type Delivered to Wholesale Market

Generation Type		CCGT		Steam Turbine		CT
Heat Rate		6800		10500		14000
Gas Price ($/MMBTU)	$	3.58	$	3.58	$	3.58
Fuel Cost ($/MWh)	$	24.37	$	37.63	$	50.18
VOM	$	2.00	$	3.50	$	4.50
Total Variable Cost	$	26.37	$	41.13	$	54.68
Losses to PX		3%		3%		3%
Delivered Cost ($/MWh)	$	27.16	$	42.37	$	56.32

The emissions costs in an hour are defined by the marginal plant based on the market prices in that hour. Based on the short-run operating costs for each unit, the cost relative to the annual average is calculated and provided in Table 7, below. For example, at the annual average market price (100% of the price), then the steam turbine is estimated to be the marginal plant. The emissions costs associated with a steam turbine are used in this hour. The variable operating costs and heat rate of the steam turbine and simple cycle gas turbine are from the CEC Staff Report "Costs to Build and Operate a Plant" included in Appendix E.

Table 7: Average Market Price and Present Value Emissions Cost

	Minimum Gen	CCGT	Steam Turbine	CT
Percent of Average Market Price	0%	64%	100%	133%
15-Year ($/kWh)	$0.048	$0.048	$0.100	$0.098
30-Year ($/kWh)	$0.079	$0.079	$0.164	$0.161

Data Sources:

B. Emissions Costs

Table 3: Emissions Cost for NOx and CO2

Table 5: Emissions Costs per MWH of Each Generation Type

Table 6: Short-run Costs by Plant Type Delivered to Wholesale Market

Table 7: Average Market Price and Present Value Emissions Cost

Plant Emission Levels

Table 4: Emissions Rates for Each Generation Type

C. 8760 Generation Shape (1991 Chronology)

D. CEC Electric Generation Price for Natural Gas

E. Costs to Build and Operate a Plant

- The losses on the bulk transmission system for delivery to the wholesale market are from a conversation with the CEC staff.

Equation 3: Weighted Average Environmental Adder

$$\textit{Environmental Adder}\left(\frac{\$}{MWh}\right)_{c,z} = \sum_{h=1}^{8760} \textit{Index Emission Cost Based On Generation Shape}\left(\frac{\$}{MWh}\right)_{h} \times \textit{Class Shape}\left(\frac{\%}{h}\right)_{h,c,z}$$

With the emissions costs calculated and the index determined, the weighted average emissions costs for residential and non-residential load profiles are calculated.

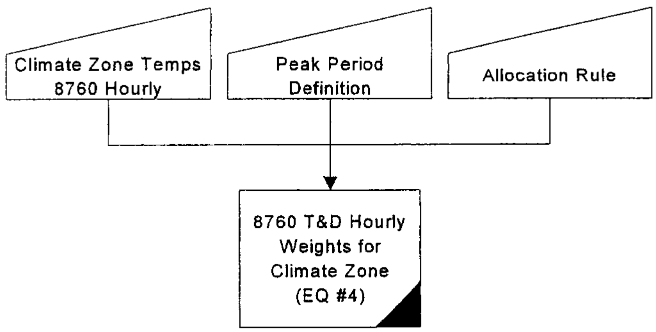
Data Sources:

C. 8760 Generation Shape (1991 Chronology)

D. Class Load Shape

- The hourly residential and nonresidential load shapes for each utility are from the statistical load profiles provided for settlement on each utility's website.
- The timing of the weekends and holidays in the 8760 stream are aligned based on the current nonresidential Title 24 ACM standard.

2.3 8760 T&D Capacity Allocation



Equation 4: 8760 T&D Hourly Weights for Climate Zone

The 8760 T&D hourly weights are calculated based on the hourly temperature profile for each climate zone based on the TMY data. The same data is used in the building simulation models so that the highest costs will be aligned with the times when buildings use the most heating and cooling. Only non-holiday weekdays as defined by the non-residential ACM manual are included as potential days for peak electric loads. Each set of weights is calculated in a separate spreadsheet and linked into TDV calculation spreadsheet.

Summer peak hours are then identified based on hourly temperature for each climate zone. Weights are then calculated proportional to how high temperatures are in the summer. The same allocation rule is used in each climate zone, however, the profile is different for each climate.

To calculate the summer T&D weights the following process is used.

1. The non-holiday weekdays are identified based on the non-residential ACM standard for building schedules.
2. The highest temperature of the 8760 TMY data-set occurring on a non-holiday weekday is identified.
3. Weights are allocated to the hours within 15 degrees of the peak temperature. The highest temperature hour gets the most weight, and the hours with temperature 15 degrees below peak get the least weight. The distribution of weights is based on a triangular weighting approach. Hours with temperatures below 15 degrees of the peak temperature do not get any weight.

This process has been carefully considered and yields results very close to a more detailed approach used by PG&E that relies on hourly load information. In areas with extreme weather, this process yields high weights to the few highest temperature hours of the year. In areas with mild weather, this process yields low weights to a large number of hours.

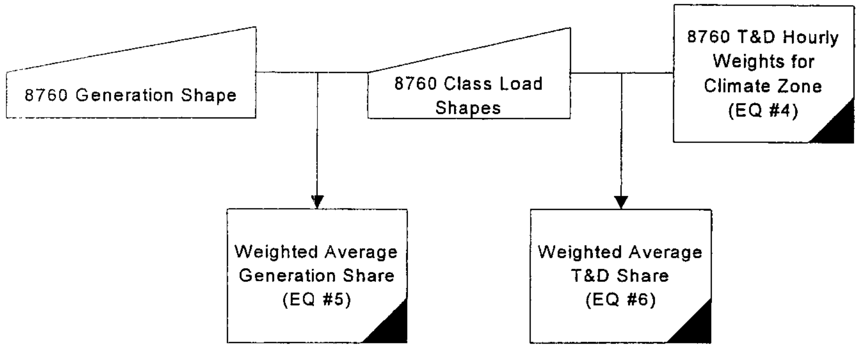
Data Sources:

1. Peak Period Definition / Allocation Rule

Climate Zone Temperatures (8760): Specific references for the Climate Zone Temperature input data can be found in the CEC Report #P400-92-004 "2001 Energy Efficiency Standards for Residential and Nonresidential Buildings," June 1, 2001 posting at the following website:

http://38.144.192.166/title24/standards/2001-10-04_400-01-024.PDF.

2.4 Weighted Average T&D and Generation Shares



Equation 5: Weighted Average Generation Share

$$Average\ Generation\ Share\,(\%\ of\ Average)_{c,z} = \sum_{h=1}^{8760} Gen\ Hourly\ Weights\,(\%\ of Average)_h \times Class\ Shape\left(\frac{\%}{h}\right)_{h,c,z}$$

To calculate the weighted average generation share, the generation cost shape is multiplied by the class load shape in each hour and then summed (vector product). This is an intermediate calculation to make it easy to calculate the average generation cost for each customer class in one step.

The following table shows the weighted average scalars for the generation component for residential and commercial classes. For example, using the consumption profile for the residential class, the average generation cost would be equal to 106% of the flat average generation shape. From this table we can see that the residential class shape is more coincident with high generation prices.

Weighted Averages	Res	Com
Gen	106%	105%

Data Sources:

C. 8760 Generation Shape (1991 Chronology)

D. Class Load Shape

Equation 4: 8760 T&D Hourly Weights for Climate Zone

Equation 6: Weighted Average T&D Share

$$Average\ T\ \&\ D\ Share\left(\frac{\%}{h}\right)_{c,z} = \sum_{h=1}^{8760} T\ \&\ D\ \ Hourly\ \ Weights\left(\frac{\%}{h}\right)_{h,z} \times Class\ \ Shape\left(\frac{\%}{h}\right)_{h,c,z}$$

To calculate the weighted average T&D share, the T&D allocation factor in each hour is multiplied by the class load shape in each hour and then summed (vector product).

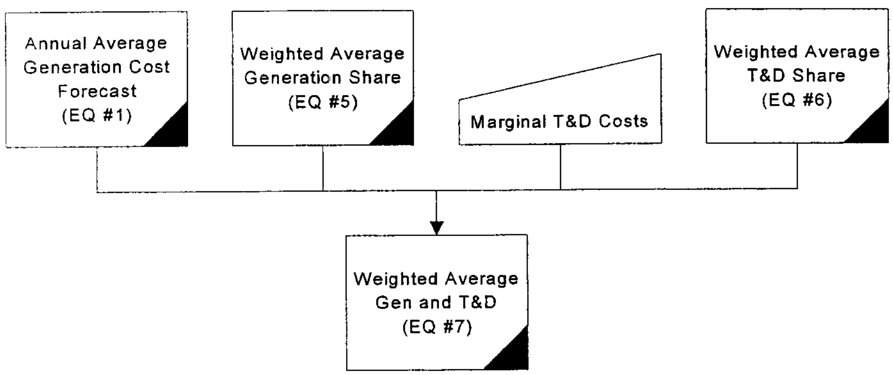
Data Sources:

C. 8760 Generation Shape (1991 Chronology)

D. Class Load Shape

Equation 4: 8760 T&D Hourly Weights for Climate Zone

2.5 Weighted Average T&D and Generation Costs



Equation 7: Weighted Average Gen and T&D

$$Average\ Gen\ and\ T\ \&\ D\ Cost\left(\frac{\$}{kWh}\right)_{c,z} = \sum_{y=1}^{15/30}\left[\frac{GenerationShare(\%ofAverage)c,z \times GenerationCost\left(\frac{\$}{kWh}\right)_{y}}{(1+r)^{y}} + \frac{T\ \&\ D\ Share\left(\frac{\$}{h}\right)_{c,z} \times T\ \&\ D\ Cost\left(\frac{\$}{kW-yr}\right)_{y}}{(1+r)^{y}}\right]$$

The weighted average generation and T&D costs are the total present value cost for each class for the generation and T&D component.

Data Sources:

G. Marginal T&D Costs

Equation 1: Annual Average Long-run Generation Cost Forecast

Equation 5: Weighted Average Generation Share

Equation 6: Weighted Average T&D Share

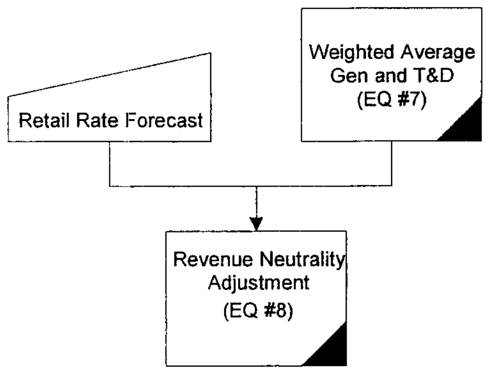
2.6 Revenue Neutrality Adjustment

Once the weighted average T&D and generation costs are calculated, a revenue neutrality adder is estimated so that the load weighted average of the T&D, generation, and revenue neutrality adder results in forecast retail rates for each class.

Retail Rate Forecast

In the years 2005 through 2012, the CEC developed the annual retail prices which reflect the "Low Reserve Margin Scenario" in the 2002-2012 Electricity Outlook Report, as described in the wholesale electricity cost section above.

Equation #8 shows the revenue neutrality adjustment calculation, which uses the electricity retail rate forecasts from the CEC.



Equation 8: Revenue neutrality adjustment

$$\text{Revenue Neutrality Adjustment}\left(\frac{\$}{kWh}\right)_{c,z} = \begin{array}{l} \text{Retail Rate Forecast}\left(\frac{\$}{kWh}\right)_{c,z} - \\ \text{Average Gen and T \& D Cost}\left(\frac{\$}{kWh}\right)_{c,z} \end{array}$$

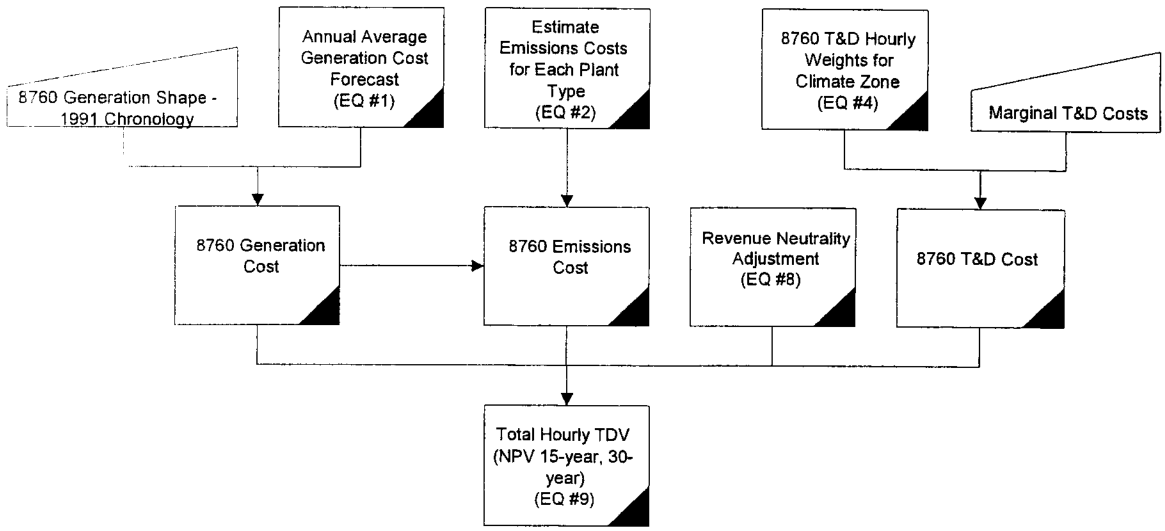
The revenue neutrality adjustment is calculated as the difference between the retail rate forecast and the total weighted average generation and T&D cost.

Data Sources.

H. California Energy Commission Monthly Retail Forecast

Equation 7: Weighted Average Gen and T&D

2.7 Total Hourly TDV Value



The final step in the process is to estimate the hourly generation, emissions, and T&D lifecycle costs, add the retail rate and the existing standard adder to derive the hourly TDV values.

Equation 9: Total Hourly TDV (NPV 15-Year, 30-Year)

$$TDV\left(\frac{\$}{kWh}\right)_{h,c,z} = \begin{array}{c} \text{Revenue Neutrality Adjustment}\left(\frac{\$}{\text{kWh}}\right)_{c,z} + \\ \text{8760 Emissions Cost}\left(\frac{\$}{\text{kWh}}\right)_{h,c,z} + \\ \text{8760 Generation Cost}\left(\frac{\$}{\text{kWh}}\right)_{h,c,z} + \\ \text{8760 T \& D Cost}\left(\frac{\$}{\text{kWh}}\right)_{h,c,z} \end{array}$$

Where

$$8760\ \textit{Emissions Cost}\left(\frac{\$}{kWh}\right)_{h,z} = \textit{Hourly Emissions Cost Based on the Index of Generation Shape}$$

$$8760\ \text{Generation Cost}\left(\frac{\$}{kWh}\right)_{h,z} = \text{8760 Hourly Generation Shape}(\%\text{of Average})_h \times \sum_{y=1}^{15/30} \frac{\text{Annual Average Generation Cost}\left(\frac{\$}{kWh}\right)_{y,z}}{(1+r)^y}$$

$$8760\ \text{T \& D Cost}\left(\frac{\$}{kWh}\right)_{h,z} = 8760\ \text{T \& D Allocation}\left(\frac{\%}{\text{h}}\right)\times\sum_{y=1}^{15/30}\frac{T\ \&\ D\ Cost\left(\frac{\$}{kW\cdot yr}\right)_y}{(1+r)^y}$$

Data Sources:

C. <u>8760 Generation Shape (1991 Chronology)</u>

G. <u>Marginal T&D Costs</u>

8760 Generation Cost (as calculated above)

8760 Emission Cost (as calculated above)

8760 T&D Cost (as calculated above)

Equation 1: Annual Average Long-run Generation Cost Forecast

Equation 2: Estimate Generation Emissions Costs by Hour

Equation 4: 8760 T&D Hourly Weights for Climate Zone

Equation 8: Revenue neutrality adjustment

3.0 Natural Gas TDV Calculations

3.1 Natural Gas Retail Price Forecast

The CEC forecast developed by the Demand Analysis Office, Fuels Division, provides the long-run wholesale and retail rate forecast for the development of the TDV values for natural gas in the years 2005 through 2034. Specific information on the forecasting methodology can be found in the "1998 Natural Gas Market Outlook Staff Report", published by the California Energy Commission in June 1998. The methodology described in the Outlook Report only represents 20 years of forecast data. The CEC staff extrapolated forecasts beyond that period in order to reach the 2034 horizon of this TDV analysis. As of March 2002, the following link points to the Outlook Report:

- http://www.energy.ca.gov/reports/98_natural_gas_outlook.html

The natural gas retail forecasts used in the TDV analysis are based up the results from the North American Regional Gas (NARG) model commodity forecasts. The California border prices are determined from the model for the core residential, commercial, and small industrial market groups and then interstate transition costs are added to this value in order to obtain the retail forecasts. Transition costs include utility costs such as transmission and distribution, margin, and fees and are weighted using an average volume cost for each customer class given the utility's cost of service estimates. The costs are monthly in year 2000 real dollars for years 2001 through 2035.

Equation #10 reflects the adoption of the CEC Monthly Forecasted Retail Rates for natural gas in the TDV calculations.

CEC Monthly
Forecasted Retail
Rates
(EQ #10)

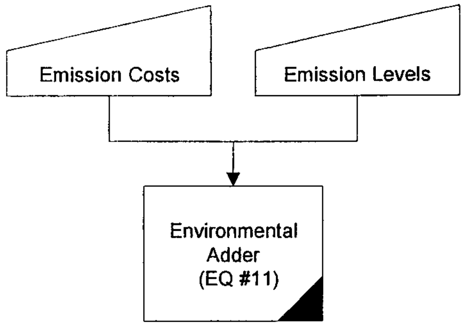
Equation 10: Annual Average Natural Gas Forecast

$$\textit{Monthly Retail Gas Cost}\left(\frac{\$}{MMBtu}\right)_{m,y,z} = \sum_{y=1}^{15/30} \textit{CEC Forecast of Retail Prices}\left(\frac{\$}{MMBtu}\right)_{m,y,z}$$

Data Sources

H. <u>California Energy Commission Monthly Retail Forecast</u>

3.2 Emissions Costs



Equation 11: Environmental Adder

$$Environmental\ Adder\left(\frac{\$}{MMBtu}\right) = \sum_{y=1}^{15/30} \frac{Emission\ Cost\left(\frac{\$}{ton}\right) \times Emission\ Level\left(\frac{tons}{MMBtu}\right)}{[1+r]^{y}}$$

The environmental adder for natural gas does not vary in time like the environmental adder for electricity. The same amount of pollutants are emitted from the combustion of natural gas regardless of the time of year. The environmental adder is calculated by multiplying the amount of emissions by the price of emissions. The following table shows the assumptions for emissions per Btu of natural gas combustion, the cost per ton of emissions, the total cost per MMBtu, and the present value total cost. For example, the present value of reducing the combustion of one MMBtu of natural gas a year for 30 years is $12.17.

		NOx		CO2
Tons/MMBtu		0.0000225		0.058
$2001 Dollars				
Externality Cost $/Ton	NOx		CO2	
E3 Recommendation	$	3,069	$	9
Emissions Cost				
$/MMBtu $2001 Dollars				
$	0.60			
$/MMBtu				
Weighted Average Environmental Adder				
	15 Year NPV	30 Year NPV		
	$7.41	$12.17		

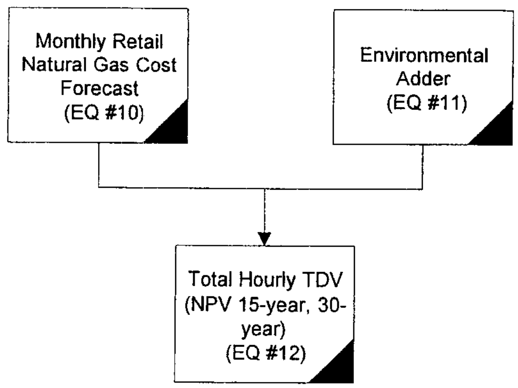
Data Sources:

B. <u>Emission Costs / Emission Levels</u>

3.3 Natural Gas TDV Values

Natural Gas Retail Forecast

The monthly retail natural gas price and the environmental adder are combined to calculate the natural gas TDV values.



Equation 12: Total Hourly TDV (NPV 15-Year, 30-Year)

$$\text{TDV Values}\left(\frac{\$}{MMBtu}\right)_{m,z,c} = \text{Monthly Retail Gas Forecast}\left(\frac{\$}{MMBtu}\right)_{m,z} + \text{Environmental Adder}\left(\frac{\$}{MMBtu}\right)$$

Data Sources:

Equation 10: Annual Average Natural Gas Forecast

Equation 11: Environmental Adder

4.0 Propane TDV Calculations

4.1 Propane Commodity Forecast

DOE sources show the long-term (15-year) relationship between Crude Oil and Propane prices, see Figure 4 : DOE Chart Showing the Relationship of Propane and Crude Oil. Recent data would indicate an inverse relationship between the two prices, see Figure 5. However, this divergence occurred during the California electricity crisis of 2000/2001 and since then prices appear to be realigning, indicating that the forecasted crude oil price escalators remain relevant for forecasting the propane prices.

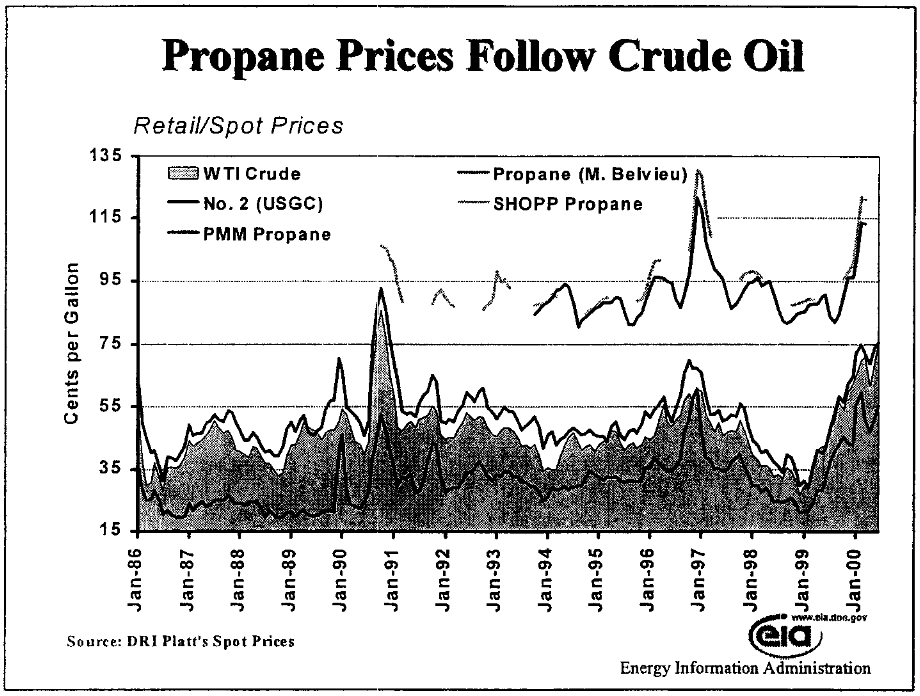


Figure 4 : DOE Chart Showing the Relationship of Propane and Crude Oil

Figure 4 shows propane prices (both spot and retail) as well as spot heating oil and crude. As you can see, most prices track the price of crude oil; when crude oil goes up so do product prices. Hence, crude oil is the major driver behind product price swings.

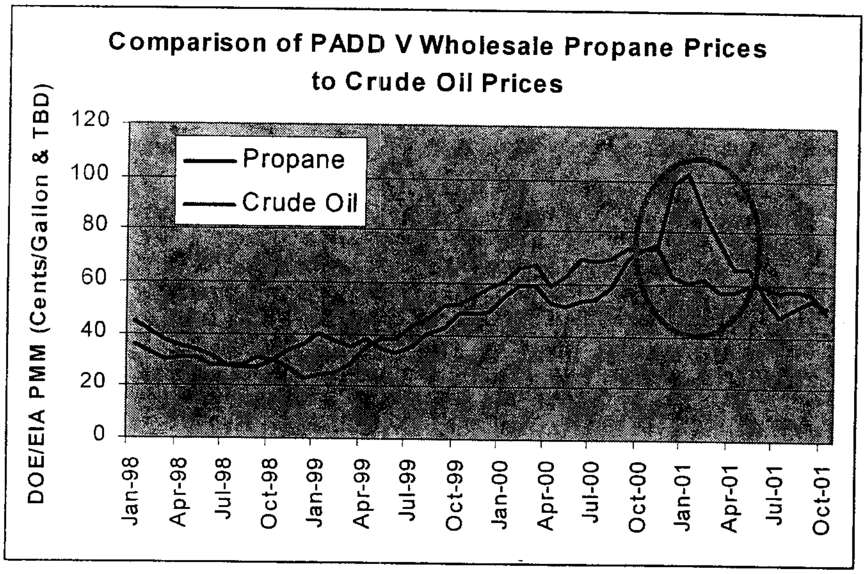


Figure 5: Recent History of Propane and Crude Oil Prices for PADD V

The current forecast uses the heating season from June 1999 through May 2000 as the base year for forecasting propane. Typically we would want to use the latest available prices and update the forecast. However, as can be seen in Figure 6 the year June 2000 through May 2001 had unusually high prices, reflecting the period of the California electricity crisis. If we were to use the 2000/2001 prices the baseline wholesale propane cost would increase from 48.62 cents/gallon to approximately 80 cents/gallon.

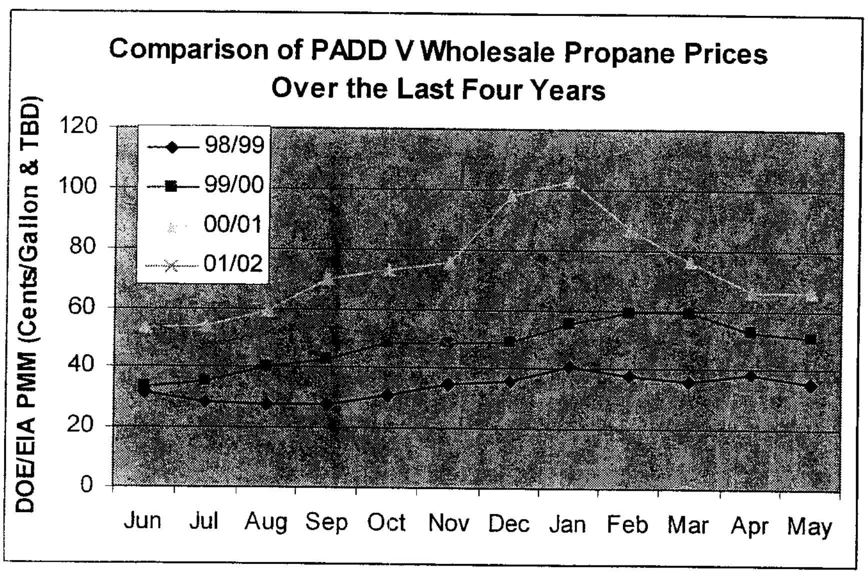
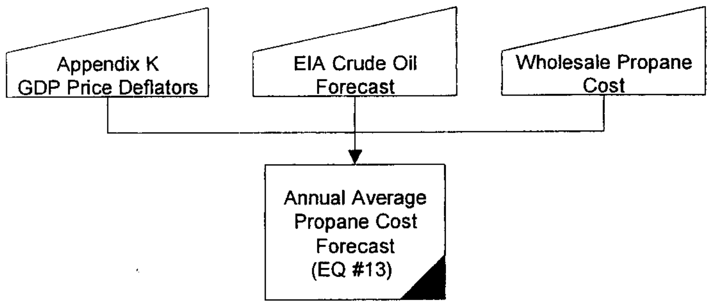


Figure 6: History of Propane Prices Over the Last Three and a Half Years



Equation 13: Annual Average Propane Cost Forecast

$$Annual\ Average\ Propane\ Cost\left(\frac{\$}{MMBtu}\right)_y = \begin{matrix} Escalation\ in\ Crude\ Oil\ Price(\%\ of\ Base\ Price)_y \times \\ Base\ Wholesale\ Propane\ Cost\left(\frac{\$}{MMBtu}\right) \end{matrix}$$

Equation #13 forecasts the wholesale propane costs by escalating the average 1999/2000 commodity cost (adjusted for inflation) with factors derived from the DOE/EIA crude oil forecasts.

Year 1999/2000 Commodity cents/gallon $2000	$	48.62
Petroleum Marketing Monthly, EIA, DOE	PAD V	

		Present Value	
		15-Year	$65.34
		30-Year	$110.44
Year	Crude Oil Forecast	Propane $/Gallon $2001	Propane Commodity $2001
2000	100%		
2001	95%	$ 0.47	$ 5.14
2002	95%	$ 0.47	$ 5.17
2003	96%	$ 0.48	$ 5.20
2004	96%	$ 0.48	$ 5.22
2005	97%	$ 0.48	$ 5.25
2006	97%	$ 0.48	$ 5.28
2007	98%	$ 0.49	$ 5.30
2008	98%	$ 0.49	$ 5.33
2009	99%	$ 0.49	$ 5.35
2010	99%	$ 0.49	$ 5.38
2011	100%	$ 0.50	$ 5.41
2012	100%	$ 0.50	$ 5.43
2013	101%	$ 0.50	$ 5.46
2014	101%	$ 0.50	$ 5.49
2015	102%	$ 0.51	$ 5.52
2016	102%	$ 0.51	$ 5.54
2017	103%	$ 0.51	$ 5.57
2018	103%	$ 0.51	$ 5.60
2019	104%	$ 0.52	$ 5.62
2020	104%	$ 0.52	$ 5.65
2021			$ 5.68
2022			$ 5.70
2023			$ 5.73
2024			$ 5.76
2025			$ 5.78
2026			$ 5.81
2027			$ 5.84
2028			$ 5.86
2029			$ 5.89
2030			$ 5.92

Years 2021 and onward forecasted using ten year trend

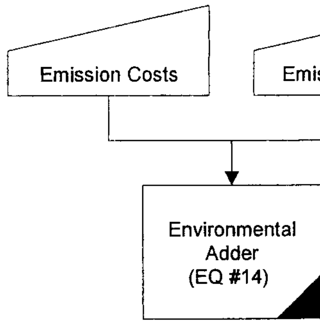
Data Sources

I. GDP Price Deflators

J. EIA Crude Oil Forecasts

K. Wholesale Propane Costs

4.2 *Emissions Costs*



Equation 14: Environmental Adder

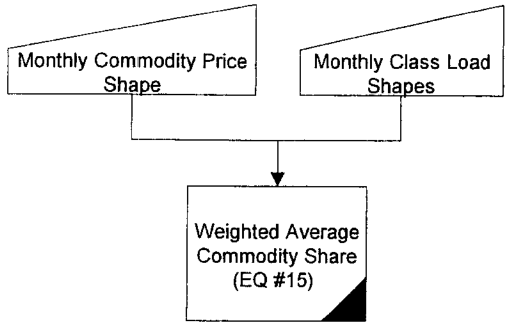
$$\text{Environmental Adder}\left(\frac{\$}{\text{MMBtu}}\right) = \sum_{y=1}^{15/30} \frac{\text{Emission Cost}\left(\frac{\$}{\text{ton}}\right) \times \text{Emission Level}\left(\frac{\text{tons}}{\text{MMBtu}}\right)}{[1+r]^y}$$

	NOx	CO2
Tons/MMBtu	0.0000225	0.07
$2001 Dollars		
Externality Cost $/Ton	NOx	CO2
E3 Recommendation	$ 3,069	$ 9
Emissions Cost		
$/MMBtu $2001 Dollars		
$ 0.71		
$/MMBtu		
Weighted Average Environmental Adder		
	15 Year NPV	30 Year NPV
	$8.77	$14.40

Data Sources:

B. Emission Costs / Emission Levels

4.3 Weighted Average Commodity Price



Equation 15: Weighted Average Commodity Share

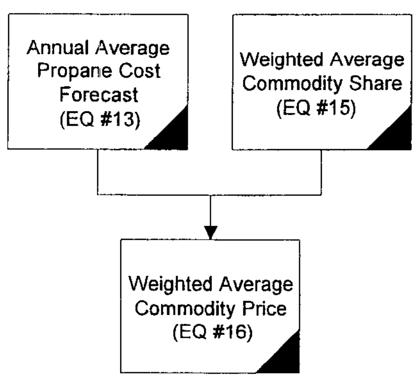
$$\textit{Weighted Average Commodity Share}(\%\ \textit{of Annual Average}) = \sum_{m=1}^{12} \textit{Monthly Commodity Price Share}(\%\ \textit{of Annual Average})_m \times \textit{MonthlyClassLoadShape}\left(\frac{\%}{m}\right)_{c,z,m}$$

Class specific load shapes were not available for propane, so the shape of the total consumption was used to calculate the average commodity. Using the total propane consumption pattern, and the wholesale market price shape results in a weighted average of 100%. This is by definition since the all of the propane sales are included. However, this calculation has been included in case consumption patterns by customer class become available.

Data Sources:

L. Monthly Commodity Price Shape

M. Monthly Class Load Shape



Equation 16: Weighted Average Commodity Price

$$WeightedAverageCommodityPrice\left(\frac{\$}{MMBtu}\right) = \sum_{y=1}^{15/30} \frac{Weighted\ Average\ Commodity\ Share(\%ofAnnualAverage) \times Propane\ Forecast}{[1+r]^y}$$

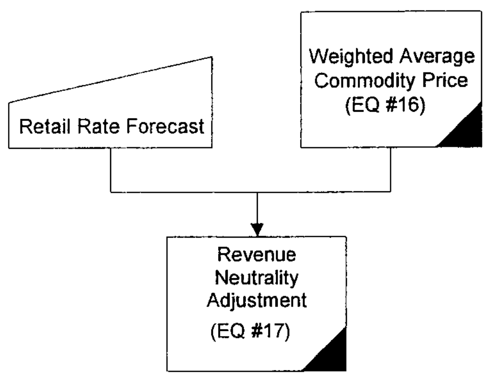
Present Value	
15-Year	$65.34
30-Year	$110.44

Data Sources:

Equation 13: Annual Average Propane Cost Forecast

Equation 15: Weighted Average Commodity Share

4.4 Revenue Neutrality Adjustment



Equation 17: Revenue neutrality adjustment

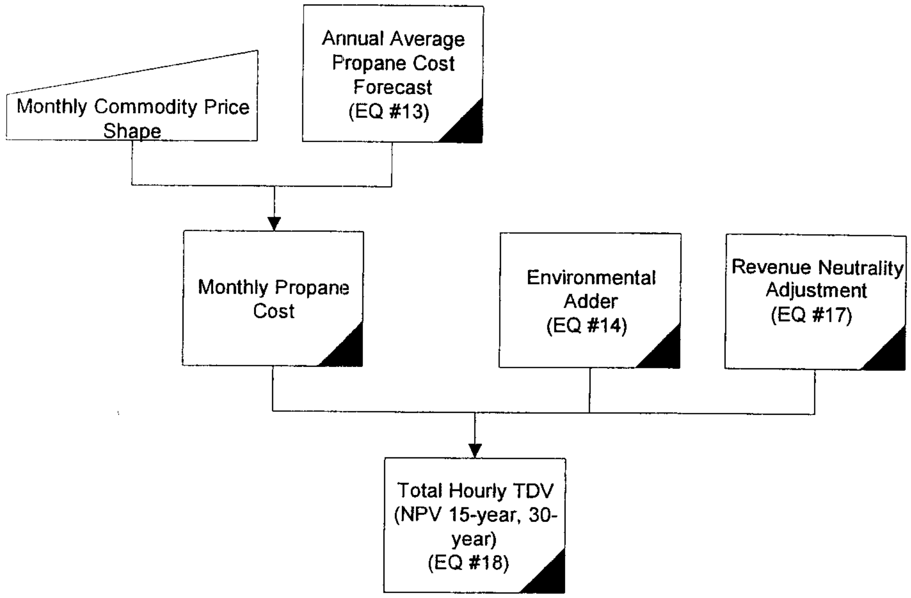
$$\text{Revenue. Neutrality Adj.}\left(\frac{\$}{\text{MMBtu}}\right)_c = \sum_{y=1}^{15/30} \frac{\text{Escalation in Oil Price}(\%\text{ of Base Price})_y \times \text{Year}_{2000}\ \text{Propane Price}\left(\frac{\$}{\text{MMBtu}}\right)_c}{(1+r)^y} - \text{Weighted Average Commodity Price}\left(\frac{\$}{\text{MMBtu}}\right)$$

The revenue neutrality adjustment is a flat adder to each hour of the year that is the difference between the commodity cost and the forecasted retail rate.

Data Sources:

Equation 16: Weighted Average Commodity Price

4.5 Propane TDV Values



Equation 18: Total Hourly TDV (NPV 15-Year, 30-Year)

$$\text{TDV Values}\left(\frac{\$}{\text{MMBtu}}\right)_{m,c} = \begin{array}{l} \text{Monthly Propane Cost}\left(\frac{\$}{\text{MMBtu}}\right)_c + \\ \text{Environmental Adder}\left(\frac{\$}{\text{MMBtu}}\right)_y + \\ \text{Revenue Neutrality Adjustment}\left(\frac{\$}{\text{MMBtu}}\right)_c \end{array}$$

Where:

$$\text{Monthly Gas Cost}\left(\frac{\$}{\text{MMBtu}}\right)_m = \begin{array}{l} \text{Monthly Commodity Price Shape}(\%\text{of Annual Average})\times \\ \sum_{y=1}^{15/30} \dfrac{\text{Average Propane Commodity Price}\left(\frac{\$}{\text{MMBtu}}\right)^y}{(1+r)^y} \end{array}$$

Data Sources.

L. Monthly Commodity Price Shape

Monthly Propane Cost: Equation 13: Annual Average Propane Cost Forecast * K. Monthly Commodity Price Shape

Equation 14: Environmental Adder

Equation 17: Revenue neutrality adjustment

Source Energy: the different types of purchased, non-renewable energy consumed on site are converted to common units in British Thermal Units (Btu) per increment of purchased energy based on the yearly average Time Dependent Valuation (TDV) for each fuel. The following are the factors for residential customers: electricity – 13,760 Btus/kWh; natural gas – 105,080 Btus/therm; propane – 157,131 Btu/gallon; fuel oil – 231,967 Btus/gallon. For non-residential customers the factors are: electricity – 19,100 Btu/kWh; natural gas – 94,690 Btu/therm; propane – 167,041 Btu/gallon; 253,826 Btu/gallon.

Source Energy

The use of energy at the site is made difficult when there are a variety of types of energy being used. Normally electricity and natural gas are consumed, but it is possible that propane, fuel oil, and other types of fuels can also be used. Increasingly, these are offset by the use of renewable sources such as photovoltaic-generated electricity, wind-produced electricity, and solar-heated water. All of these need to be fairly judged. The easy answer of the cost-per-standard-unit of energy does not work because of the volatility and large variety of tariffs and purchasing situations. Also, if on-site renewable energy production or energy conservation displaces non-renewable energy, the accounting system must be in a metric that does this accurately. For 30 years, the State of California used the fixed-source energy multiplier, which accounted for the energy content of commonly site-consumed energy, as shown in the table below.

Energy Source	Source Energy Multiplier	BTU per Unit of Consumption
Electricity	3	10,239 Btu/kilowatt hour
Natural Gas	1	100,000 Btu/therm
Fuel Oil	1	138,400 Btu/gallon
LPG	1	91,080 Btu/gallon

The heightened interest in energy efficiency and peak demand on the electric grid, caused in part by the energy crisis of 2000 and 2001, led to the development of a refined analysis of the source energy multipliers. The new methodology is built on the fact that hourly computer analysis simulations are standard practice in the building industry for code compliance. Also, California electric and natural gas utilities were able to supply the necessary hourly data to support the Climate Zone by Climate Zone variation of transmission and distribution costs needed to go with other economic and environmental factors. The result is called the Time Dependent Valuation of Energy or TDV. The 2005 California Building Energy Efficiency Standards that go into effect on October 1, 2005, require the use of TDV.

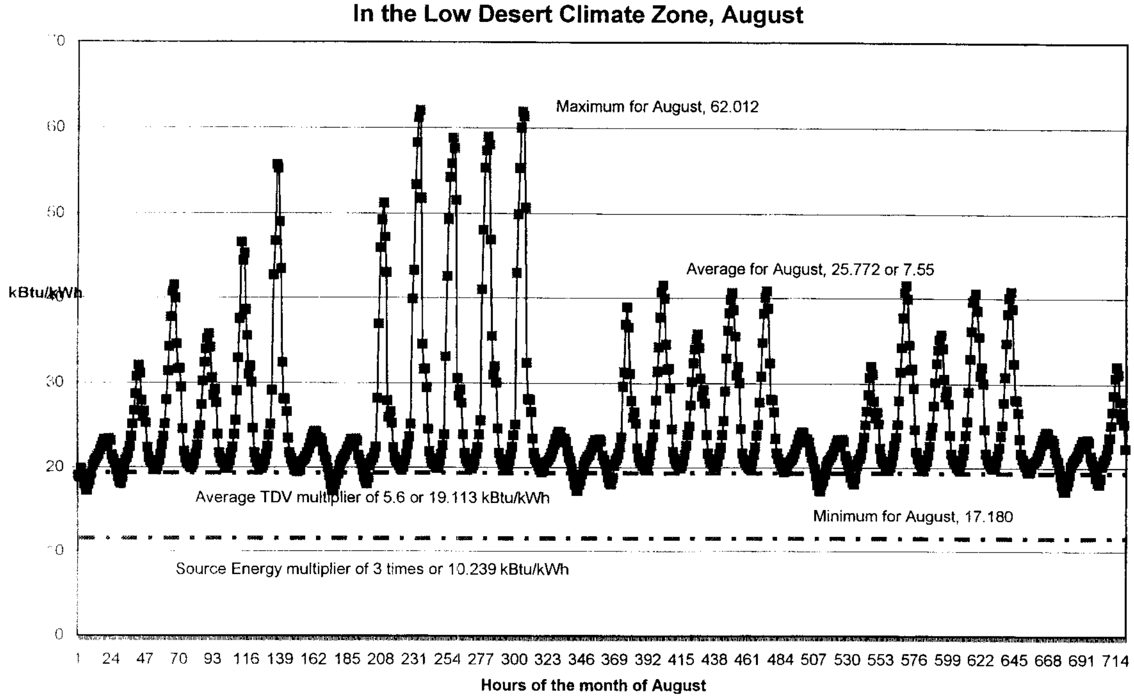
The impact of TDV is illustrated by the minimum, average, and maximum values of the multipliers for non-residential customers in the high desert (Climate Zone 14) and low desert (Climate Zone 15). The table below displays the new 2005 values.

Climate Zone	Energy Source	Source Energy Multiplier – Minimum	Source Energy Multiplier – Average	Source Energy Multiplier - Maximum
High Desert (CZ 14)	Electricity	2.63	5.60	21.29
	Natural Gas	0.8775	0.9468	1.0437
	Propane	1.6518	1.8340	1.9868
Low Desert (CZ15)	Electricity	2.61	5.60	21.68
	Natural Gas	0.8775	0.9468	1.0437
	Propane	1.6518	1.8340	1.9868
Silicon Valley (CZ4)	Electricity	2.59	4.95	30.81

The low and high desert examples have climates that begin to approximate those of Arizona's most populated regions. The Silicon Valley example shows the impact of a mild climate but a highly constrained transmission grid, which yields the highest multiplier for all of the 16 climate zones in the state. A review of the hourly data shows that during the summer months, the minimum for the low desert is 2.63, and the average becomes 6.33. Thus, the old fixed value of 3.00 is not a true representation of the value of saving electricity in the summer. The natural gas values in the summer stay near 1.0, but do vary on a monthly base.

The super peaks are graphically displayed in the following plot of the TDVs for the month of August.

Time Dependent Value of kWh for Non-Residential Customers
In the Low Desert Climate Zone, August



The graph demonstrates why the old fixed value of three times is inadequate for public policy and should at a minimum be replaced by the yearly average value of the TDV analysis. The numeric impact is best seen when a comparison of the cost and TDV source energy for the four most common household applications are calculated.

Comparison of Household Electric or Natural Gas Applications: Cost, Fixed Source and Time Dependent Valuation of Energy Source Energy Multipliers

Unit Energy Consumption all Single Family Homes					Average TDV	
Application	kWh/year	Cost Electricity	therms/yr	Cost Natural Gas	Electricity at 4.03	Natural Gas at 1.0508
Water Heat	2762	$ 248.58	143	$ 143.00	37,989,625	15,026,440
Dryer	774	$ 69.66	40	$ 40.00	10,645,898	4,203,200
Range/Oven	381	$ 34.29	38	$ 38.00	5,240,423	3,993,040
Heating	1560	$ 140.40	140	$ 140.00	21,456,848	14,711,200
	5477	$ 492.93	361	$ 361.00	53,875,946	23,222,680
			Total Savings	$ 131.93		30,653,266

Gas Cost	$	1.00
Electric Cost	$	0.09
TDV Elect Res		4.03
TDV NG Res		1.0508

The gas and electric cost data can be changed as required for the service territory and tariff. The dollar savings will vary, but the source energy savings will always be in favor of the direct use of natural gas instead of the indirect use of natural gas to produce electricity. The average multipliers for residential customers are 4.03 for electricity and 1.0506 for natural gas. The multipliers for non-residential customers are 5.6 for electricity and 0.95 for natural gas, as required by the different nature of the supply, distribution and consumption patterns between the two types of customers. These two web addresses give details about the implementation of TDV in the California Building Energy Efficiency Standards (Title 24) and the background on the development of TDV: Appendix III of the 2005 Joint Appendices.

http://www.energy.ca.gov/2005_standards/rulemaking/documents/15-day_language/2003-10-21_400-03-001JAET15.PDF, and

http://www.energy.ca.gov/2005_standards/rulemaking/documents/tdv/TDV_COOKBOOK.PDF.